(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 951 151 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
13.12.2006 Bulletin 2006/50

(51) Int Cl.:
H04B 7/005 (2006.01) ***H04L 27/34*** (2006.01)

(21) Application number: **99107576.3**

(22) Date of filing: **15.04.1999**

(54) Pilot signal transmission technique and digital communication system using same

Pilotsignalsnübertragungstechnik und diesen verwendendes digitales Kommunikationssystem

Technique de transmission de signal pilote et système de communication numérique utilisant une telle technique

(84) Designated Contracting States:
DE FR GB

(30) Priority: **16.04.1998 JP 10599098**

(43) Date of publication of application:
20.10.1999 Bulletin 1999/42

(73) Proprietor: **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**
Kadoma-shi, Osaka 571-8501 (JP)

(72) Inventors:
- **Murakami, Yutaka**
  Yokohama 230-0074 (JP)
- **Orihashi, Masayuki**
  Ichikawa-shi,
  Chiba-ken 272-0001 (JP)
- **Matsuoka, Akihiko**
  Yokohama, 226-0021 (JP)
- **Sagawa, Morikazu**
  Inagi-shi,
  Tokyo 206-0821 (JP)

(74) Representative: **Manitz, Finsterwald & Partner GbR**
Martin-Greif-Strasse 1
80336 München (DE)

(56) References cited:
EP-A- 0 668 664
EP-A- 0 810 743
WO-A-98/12678
US-A- 5 381 449
US-A- 5 712 877

Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a digital communications system and more specifically to modulation methods facilitating fading distortion compensation that performs a quasi-synchronous detection using a pilot signal.

2. Description of the Prior Art

[0002] In a digital communications system, especially in a digital mobile radio system, the envelope of information signals or symbols is distorted (i.e., the phases and the amplitudes of information signals involves phase errors and amplitude errors) due to fading. The phase error of the received signal causes an error in the frequency of a local oscillator in the receiver. The error of the local oscillation frequency with respect to the carrier frequency is hereinafter referred to as a "frequency offset". The phase error (or frequency offset) and the amplitude error of the received signal have to be estimated and compensated for in the receiver.

[0003] A fading distortion compensation scheme using a pilot signal is described by S. Sampei, "Rayleigh Fading Compensation Method for 16-QAM MODEM in Digital Land Mobile Radio Systems," Trans. IEICE (The Institute of Electronics, Information and Communication Engineers) Japan, Vol. J72-B-II, No. 1, January 1989, pp. 7-15. FIG. 1 is a diagram showing a signal constellation used in this 16-QAM system. In FIG. 1, small black-filled circles indicate 16 signal points in an in-phase (I) and quadrature-phase (Q) plane. One of the signal points with the maximum amplitude, that is, any of the signal points A, B, C and D is assigned to a pilot signal. (Since one of the 16 signal points in the signal constellation is used for a pilot signal, the remaining 15 points are available for the information signals.) A pilot signal is inserted in every frame or every N-1 information symbols (assuming that N symbols constitute one frame) in a transmitter. The estimation and compensation of distortions (due to fading) of information signals or symbols are achieved by interpolation using the pilot signals.

[0004] In such quasi-synchronous detection as just described, larger-amplitude pilot symbols yields a higher precision in estimation of the frequency offset and the amplitude error of the information signals, which results in an improvement of the bit error rate, which is a function of the ratio of the carrier signal power to the noise power density per one symbol. However, enlarging the amplitude of the pilot signals without taking any measure lowers the power efficiency of the power amplifier of the transmitter system due to an increase in the ratio of the peak to the average transmission power.

[0005] In EP-A-0 668 664, a CDMA/TDD radio communication system is disclosed. In this system, in addition to a structure of a conventional CDMA/TDD radio communication system, a base station includes a pilot signal generating circuit for generating a pilot signal that has a constant transmission power level and is known in mobile units and a pilot channel spreading circuit for transmitting the pilot signal to the mobile units through a transmission line. However, in this system, when the amplitude of the pilot signal is enlarged to heighten the precision in estimation of the frequency offset and the amplitude error of the information signals, the ratio of the peak to the average transmission power is increased.

[0006] US-A-5 381 449 discloses a method of reducing a ratio of peak to average power by pre-selecting amplitude and/or phase angles for pilot symbols added to QAM information symbols in a multi-subchannel, N-level QAM communication system, so as to minimize the peak to average power ratio of a composite QAM signal that is transmitted on a communication channel. To reduce the peak to average power ratio of the composite QAM signal, non-constellation-based pilot symbols and a constellation-based pilot symbol are used.

[0007] It is an object of the invention to provide a method of and a system for compensating for fading distortion of the received signal with a raised precision and thereby to provide a digital communication system that permits a reception of a reduced bit error rate.

[0008] The object is met by a method according to claim 1, by a system according to claim 14 and by a mobile telephone according to claim 27.

SUMMARY OF THE INVENTION

[0009] In accordance with the principles of the invention, a point that differs in phase from any of the signal points for possible information symbols and that is larger in amplitude than any of the signal points is selected for a pilot signal point in a signal constellation (or a signal point map plotted on a in-phase and quadrature-phase plane). A pilot signal is inserted in every frame or every predetermined number of information signals.

[0010] In a receiver, the fading distortion of each of the pilot signals regularly inserted in the received signals is determined. The fading distortions of the information signals are estimated by interpolation using the determined fading distortion of the pilot signal, and then compensated for.

[0011] In a preferred embodiment, the amplitude of the pilot signal is set not larger than 1.6 times a maximum possible amplitude of the information signals.

[0012] The frequency band of each information signal is preferably limited with a roll-off filter with a roll-off coefficient ranging from 0.1 to 0.4.

BRIEF DESCRIPTION OF THE DRAWING

[0013] The features and advantages of the present invention will be apparent from the following description of an exemplary embodiment of the invention and the accompanying drawing, in which:

FIG. 1 is a diagram showing a signal constellation used in this 16-QAM system;
FIG. 2 is a schematic block diagram showing a part of an illustrative embodiment of a mobile telephone terminal that incorporates a fading distortion compensation system in accordance with the principles of the invention;
FIG. 3 is a diagram of an exemplary signal constellation for 16-APSK (amplitude phase shift keying) used in an example which is not covered by the invention;
FIG. 4 is a diagram showing a symbol stream transmitted in a digital communication system that serves the mobile telephone terminal 1 of FIG. 1;
Fig. 7 is a signal constellation for 8-PSK which is not covered by the invention; and
FIGs. 5, 6 and 8 are signal constellations for ^{m}-QAM, 16-QAM, and QPSK according to the principles of the invention.

[0014] Throughout the drawing, the same elements when shown in more than one figure are designated by the same reference numerals.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] FIG. 2 is a schematic block diagram showing a part of an illustrative embodiment of a mobile telephone terminal 1 that incorporates a fading distortion compensation system in accordance with the principles of the invention. A transmission system (shown in upper part of FIG. 2) of the mobile telephone terminal 1 includes a serial-to-parallel (S/P) converter 10; a base band signal generator 20 having its input connected with a converter 10 output; a pilot (or frame) signal inserter 110 having its in-phase (I) input and quadrature-phase (Q) input connected with respective outputs of the base band signal generator 20; low pass filters (LPF) 30 having their inputs connected with pilot signal inserter 110 outputs; a radio transmitter portion 40 having its I and Q inputs connected with I and Q LPF 30 outputs, respectively; an antenna duplexer 50 having transmission input connected with the transmitter portion 40 output; and an antenna 60 used for both transmission and reception. A reception system (shown in lower part of FIG. 2) of the mobile telephone terminal 1 includes a radio receiver portion 70 having its input connected with a duplexer 50 reception output; LPFs 80 having their input connected with radio receiver portion 70 I and Q outputs; a fading distortion compensator 100 having its I and Q inputs connected with respective LPF 80 outputs; and a decision maker 90, having its input connected with a compensator 100 output, for providing received data. The fading distortion compensator 100 includes a phase error estimator 120, an amplitude error estimator 130 and a phase and amplitude compensator 140. The mobile telephone terminal 1 further includes a controller 170 for controlling overall operation of the terminal 1.

[0016] In transmission operation, binary data is supplied in the form of a bitstream to the S/P converter 10. The S/P converter 10 converts the serial binary data into a parallel data of a predetermined number of bits. The base band signal generator 20 generates an in-phase (I) and quadrature-phase (Q) components or signals for a symbol associated with the parallel data.

[0017] FIG. 3 is a diagram of an exemplary signal constellation for 16-APSK (amplitude phase shaft keying) used in an example which is not covered by the invention. FIG. 4 is a diagram showing an operation of the pilot signal inserter 110 of FIG. 3. In FIGs. 3 and 4 and the following figures of signal communications, small black-filled circles indicate information symbols and small white-filled circles indicate pilot (or frame) symbols.

[0018] In this specific example, the base band signal generator 20 generates I and Q components of one (ISi) of the 16 possible information symbols IS_1, IS_2,..., IS_P which is associated with each of the parallel data supplied to the generator 20, where i = 1, 2,....P, and P is the number of possible information symbols (16 in this specific example) in the modulation scheme. The information symbol stream supplied from the base band signal generator 20 is shown in the upper part of FIG. 4.

[0019] The pilot signal inserter 110 inserts a pilot signal PS in every predetermined number of information symbols, say, N-1 symbols S_1,...S_{N-1} to make a frame of N symbols S_0, S_1,...S_{N-1} as shown in FIG. 4. In each frame of the symbol stream output from the pilot signal inserter 110,

$$Sj = \begin{cases} PS & \text{for } j = 0 \\ IS_i & \text{for } j = 1, 2, \dots, N\text{-}1. \end{cases} \quad \cdots\cdots\cdots (1)$$

[0020] It is seen from FIG. 3 that the pilot signal PS (=So) is preferably disposed so as to make an angle of $\pi/8$ with adjacent information signal points. Thus, the pilot signal PS = (PSI, PSQ) is preferably set to any of the following points:

$$PS_I = R^* \cos(\frac{i\pi}{4} + \frac{\pi}{8})$$

$$PS_Q = R^* \sin(\frac{i\pi}{4} + \frac{\pi}{8}),$$

where i = 1,2,...,16 and R is the amplitude of the pilot signal PS.

[0021] The amplitude R of the pilot signal PS is set larger than that of any information signal Sj (= ISi), Ri, as shown in FIG. 3. Specifically, it is preferable to set the pilot signal amplitude R for a range larger than the maximum amplitude Rmax of the information symbols and not larger than 1.6 times the maximum amplitude Rmax, that is,

$$Rmax < R \leqq 1.6^*Rmax. \quad \cdots\cdots\cdots (2)$$

[0022] It is noted that each signal Sj is processed in the form of corresponding I and Q components Sj_I and Sj_Q. The signals Sj from the pilot signal inserter 110 is limited in frequency band by the LPFs 30. The LPFs 30 are preferably roll-off filters (or Nyquist filters) having the following characteristic:

$$H(\omega) = \begin{cases} 1.. & \cdots \ \omega \le \omega_0(1-\alpha) \\ \sqrt{\frac{1}{2}[1 - \sin\left(\frac{\pi}{2\alpha\omega_0}(\omega - \omega_0)\right)]} & \cdots \ \omega_0(1-\alpha) \le \omega \le \omega_0(1+\alpha) \\ 0 & \cdots \ \omega \ge \omega_0(1+\alpha). \end{cases}$$

$$\cdots\cdots\cdots (3)$$

where $H(\omega)$ is a amplitude characteristic of the roll-off filters 30, ω is an angular frequency, ω_0 is a Nyquist angular frequency and a is a roll-off coefficient. It is preferable to set the roll-off coefficient α for a range from 0.1 to 0.4.

[0023] The filtered signals are modulated and amplified by the radio transmitter portion 40, and eventually transmitted via the duplexer 50 and the antenna 60.

[0024] In reception operation, the I and Q components of the received signals received by the antenna 50, the duplexer 60 and the radio receiver portion 70 is filtered by the LPFs 80 and supplied to the phase error estimator 120, the amplitude error estimator 130 and the phase and amplitude compensator 140. The phase error estimator 120 provides an estimated phase error signal to the compensator 140. The amplitude error estimator 130 provides, to the compensator 140, an estimated amplitude error signal for each information signal Sj (j=1, 2,...N-1) through interpolation using a pilot signal S_0. The phase and amplitude compensator 140 responsively compensates each information signal by using the estimated phase and amplitude error signals to provide compensated I and Q components. The decision maker 90 provides data associated with the compensated I and Q components.

[0025] In this way, the bit error rate is reduced without influencing on the ratio of peak to average power at the amplifier (AMP) 44 in the radio transmission portion 40 because the precision in estimation of frequency and amplitude errors of the information signals is enhanced.

Modification

[0026] The invention is applicable to more-than-7-signal-point modulation schemes, such as 2^m-QAM (quadrature amplitude modulation) ($m \geqq 3$), 16-QAM, and QPSK (quadrature phase shift keying) which are presented in the following.

[0027] FIGs. 5, 6 and 8 are signal constellations for 2^m-QAM ($m \geqq 3$), 16-QAM, and QPSK according to the principles of the invention.

[0028] As for 2^m-QAM as shown in FIG. 5, if the information signal points ISi (i = 1, 2,..., 2^m) are written as (ISi_I, ISi_Q) in I-Q coordinates, the points are expressed as follows:

$$ISi_I = s(2^{m-1}a_1 + 2^{m-2}a_2 + \ldots + 2^0 a_m)$$
$$ISi_Q = s(2^{m-1}b_1 + 2^{m-2}b_2 + \ldots + 2^0 b_m) \quad \cdots\cdots\cdots\cdots (4)$$

where s is a constant and each of a_k and b_k (k = 1, 2,..m) represents 1 and -1, i.e., (a_k, b_k) represents four points (1, 1), (1, -1), (-1, 1) and (-1, -1). In this case, the pilot signal PS is disposed on either of the I and Q axes such that the amplitude (R) of PS is larger than that (Ri) of any possible symbol points. In the specific example of FIG. 5, the pilot signal is disposed on the positive range of the I axis.

[0029] In case of 16-QAM, the possible symbol points are expressed as follows:

$$ISi_I = s(2^1 a_1 + 2^0 a_2)$$
$$ISi_Q = s(2^1 b_1 + 2^0 b_2). \quad \cdots\cdots\cdots\cdots (5)$$

In this case, the pilot signal PS is preferably disposed on either of the I and Q axes such that the amplitude (R) of PS is larger than that (Ri) of any possible symbol points ISi as shown in FIG. 6

[0030] In case of 8-PSK as shown in FIG. 7, the possible signal points are expressed as:

$$ISi_I = r{*}\cos(i\pi/4)$$
$$ISi_Q = r{*}\sin(i\pi/4). \quad \cdots\cdots\cdots\cdots (6)$$

In this case, since the pilot signal PS is preferably disposed so as to make an angle of $\pi/8$ with adjacent information points, the pilot signal PS = (PSI, PSQ) is preferably set to any of the following points:

$$PS_I = R{*}\cos\left(\frac{i\pi}{4} + \frac{\pi}{8}\right)$$

$$PS_Q = R{*}\sin\left(\frac{i\pi}{4} + \frac{\pi}{8}\right)$$

where k = 1, 2,...,8 and R is the amplitude of the pilot symbol that satisfy:

$$r < R \leqq 1.6{*}r.$$

[0031] In case of QPSK as shown in FIG. 8, the possible signal points are expressed as:

$$ISi_I = r{*}\cos\left(\frac{\pi}{4}+\frac{i\pi}{2}\right)$$

$$ISi_Q = r{*}\sin\left(\frac{\pi}{4}+\frac{i\pi}{2}\right). \quad \cdots\cdots\cdots\cdots (7)$$

In this case, since the pilot signal PS is preferably disposed so as to make an angle of π/4 with adjacent information points, the pilot signal PS = (PS_I, PS_Q) is preferably set to any of the following points:

$$PS_I = R{*}\cos\left(\frac{\pi}{2}(1+i)\right)$$

$$PS_Q = R{*}\sin\left(\frac{\pi}{2}(1+i)\right).$$

[0032] It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.

Claims

1. A method of transmitting digital data by wireless in a digital wireless communications system, the method comprising the steps of:

converting digital data into a first stream of information signals having four or more signal points on an in-phase and quadrature-phase plane according to a multi-point modulation scheme;
inserting a pilot signal in said first stream of said information signals to generate a second stream of said information signals and said pilot signal, a point of said pilot signal on the in-phase and quadrature-phase plane differing in phase from any of said information signals and being placed on either of I and Q axes of the in-phase and quadrature-phase plane, and an amplitude of said pilot signal being larger than that of any of said information signals; and
transmitting said second stream by wireless.

2. A method as defined in claim 1, wherein said step of inserting a pilot signal includes the step of setting said amplitude of said pilot signal not larger than 1.6 times a maximum possible amplitude of said information signals.

3. A method as defined in claim 1, wherein said step of transmitting said second stream includes the step of:

limiting a frequency band of each information signal with a roll-off filter with a roll-off coefficient ranging from 0.1 to 0.4.

4. A method as defined in claim 1, wherein said multi-point modulation scheme is a 2^m-signal-point-quadrature amplitude modulation, where m is a positive integer not smaller than 3.

5. A method as defined in claim 1, wherein the multi-point modulation scheme is a quadrature phase shift keying modulation.

6. A method as defined in claim 5, wherein said pilot signal is so disposed as to make an angle of π/4 with adjacent information signals in said in-phase and quadrature-phase plane.

7. A method as defined in claim 5, wherein said step of inserting a pilot signal includes the step of setting said amplitude of said pilot signal not larger than 1.6 times a maximum possible amplitude of said information signals.

8. A method as defined in claim 5, wherein said step of transmitting said second stream includes the step of:

limiting a frequency band of each information signal with a roll-off filter with a roll-off coefficient ranging from 0.1 to 0.4.

9. A system comprising:

converting means (10) for converting digital data into a first stream of information signals having four or more signal points on an in-phase and quadrature-phase plane according to a multi-point modulation scheme;
inserting means (110) for inserting a pilot signal in said first stream of said information signals to generate a second stream of said information signals and said pilot signal; and
transmitting means (30; 40; 50; 60) for transmitting said second stream by wireless,

characterized in that a point of said pilot signal on the in-phase and quadrature-phase plane differs in phase from any of said information signals and is placed on either of I and Q axes of the in-phase and quadrature-phase plane, and an amplitude of said pilot signal is larger than that of any of said information signals.

10. A system as defined in claim 9, wherein said inserting means sets said pilot signal to the amplitude not larger than 1.6 times a maximum possible amplitude of said information signals.

11. A system as defined in claim 9, wherein said transmitting means includes:

means (30) for limiting a frequency band of each information signal with a roll-off filter with a roll-off coefficient ranging from 0.1 to 0.4.

12. A system as defined in claim 9, wherein said multi-point modulation scheme is a 2^m-signal-point-quadrature amplitude modulation, where m is a positive integer not smaller than 3.

13. A system as defined in claim 9, wherein said multi-point modulation scheme is a quadrature phase shifting keying modulation.

14. A system as defined in claim 13, wherein said pilot signal is so disposed as to make an angle of $\pi/4$ with adjacent information signals in said in-phase and quadrature-phase plane.

15. A system as defined in claim 13, wherein said inserting means sets said pilot signal to the amplitude not larger than 1.6 times a maximum possible amplitude of said information signals.

16. A system as defined in claim 13, wherein said transmitting means includes:

means (30) for limiting a frequency band of each information signal with a roll-off filter with a roll-off coefficient ranging from 0.1 to 0.4.

17. A mobile telephone that communicates digital data at a reduced bit error rate, the mobile telephone comprising:

a transmission system (10; 20; 110; 30; 40; 50; 60) ; and
a receiver system (70; 80; 100; 90), said transmission system including:

converting means (10) for converting said digital data into a first stream of information signals having four or more signal points on an in-phase and quadrature-phase plane according to a multi-point modulation scheme;
inserting means (110) for inserting a pilot signal in said first stream of said information signals to generate a second stream of said information signals and said pilot signal; and
transmitting means (30; 40; 50; 60) for transmitting said second stream,

characterized in that a point of said pilot signal on the in-phase and quadrature-phase plane differs in phase from any of said information signals and is placed on either of I and Q axes of the in-phase and quadrature-phase plane, and an amplitude of said pilot signal is larger than that of any of said information signals.

18. A mobile telephone as defined in claim 17, wherein said inserting means sets said pilot signal to the amplitude not larger than 1.6 times a maximum possible amplitude of said information signals.

19. A mobile telephone as defined in claim 17, wherein said transmitting means includes:

means (30) for limiting a frequency band of each information signal with a roll-off filter with a roll-off coefficient ranging from 0.1 to 0.4.

Patentansprüche

1. Verfahren zur drahtlosen Übertragung digitaler Daten in einem drahtlosen digitalen Kommunikationssystem, das die Schritte umfasst:

Umwandeln digitaler Daten gemäß einem Multipoint-Modulationsschema in einen ersten Strom von Informationssignalen mit vier oder mehr Signalpunkten auf einer Inphasen- und Quadraturphasenebene;
Einfügen eines Pilotsignals in den ersten Strom der Informationssignale, um einen zweiten Strom aus den Informationssignalen und dem Pilotsignal zu erzeugen, wobei ein Punkt des Pilotsignals auf der Inphasen- und Quadraturphasenebene in der Phase von jedem der Informationssignale abweicht und entweder auf der I- oder auf der Q-Achse der Inphasen- und Quadraturphasenebene angeordnet ist und eine Amplitude des Pilotsignals größer als die jedes der Informationssignale ist; und
drahtloses Übertragen des zweiten Stroms.

2. Verfahren nach Anspruch 1, wobei der Schritt des Einfügens eines Pilotsignals den Schritt des Einstellens der Amplitude des Pilotsignals auf nicht größer als das 1,6-fache einer maximal möglichen Amplitude der Informationssignale umfasst.

3. Verfahren nach Anspruch 1, wobei der Schritt des Übertragens des zweiten Stroms den Schritt umfasst:

Begrenzen eines Frequenzbands jedes Informationssignals mittels eines Roll-Off-Filters mit einem Roll-Off-Faktor im Bereich von 0,1 bis 0,4.

4. Verfahren nach Anspruch 1, wobei das Multipoint-Modulationsschema eine 2^m-Signalpunkt-Quadratur-Amplitudenmodulation ist, wobei m eine positive ganze Zahl nicht kleiner als 3 ist.

5. Verfahren nach Anspruch 1, wobei das Multipoint-Modulationsschema eine Quadraturphasenumtastung oder Vierphasen-Modulation ist.

6. Verfahren nach Anspruch 5, wobei das Pilotsignal so angeordnet ist, dass es mit benachbarten Informationssignalen in der Inphasen- und Quadraturphasenebene einen Winkel von $\pi/4$ bildet.

7. Verfahren nach Anspruch 5, wobei der Schritt des Einfügens eines Pilotsignals den Schritt des Einstellens der Amplitude des Pilotsignals auf nicht größer als das 1,6-fache einer maximal möglichen Amplitude der Informationssignale umfasst.

8. Verfahren nach Anspruch 5, wobei der Schritt des Übertragens des zweiten Stroms den Schritt umfasst:

Begrenzen eines Frequenzbands jedes Informationssignals mittels eines Roll-Off-Filters mit einem Roll-Off-Faktor im Bereich von 0,1 bis 0,4.

9. System, das umfasst:

ein Umwandlungsmittel (10) zum Umwandeln digitaler Daten gemäß einem Multipoint-Modulationsschema in einen ersten Strom von Informationssignalen mit vier oder mehr Signalpunkten auf einer Inphasen- und Quadraturphasenebene;
ein Einfügemittel (110) zum Einfügen eines Pilotsignals in den ersten Strom von Informationssignalen, um einen zweiten Strom aus den Informationssignalen und dem Pilotsignal zu erzeugen; und
ein Übertragungsmittel (30; 40; 50; 60) zum drahtlosen Übertragen des zweiten Stroms,

dadurch gekennzeichnet, dass ein Punkt des Pilotsignals auf der Inphasen- und Quadraturphasenebene in der Phase von jedem der Informationssignale abweicht und entweder auf der I- oder auf der Q-Achse der Inphasenund Quadraturphasenebene angeordnet ist und eine Amplitude des Pilotsignals größer als die jedes Informationssignals ist.

10. System nach Anspruch 9, wobei das Einfügemittel das Pilotsignal auf die Amplitude nicht größer als das 1,6-fache einer maximal möglichen Amplitude der Informationssignale einstellt.

11. System nach Anspruch 9, wobei dass das Übertragungsmittel umfasst:

ein Mittel (30) zum Begrenzen eines Frequenzbands jedes Informationssignals mittels eines Roll-Off-Filters mit einem Roll-Off-Faktor im Bereich von 0,1 bis 0,4.

12. System nach Anspruch 9, wobei das Multipoint-Modulationsschema eine 2^m-Signalpunkt-Quadratur-Amplitudenmodulation ist, wobei m eine positive ganze Zahl nicht kleiner als 3 ist.

13. System nach Anspruch 9, wobei das Multipoint-Modulationsschema eine Quadraturphasenumtastung oder Vierphasen-Modulation ist.

14. System nach Anspruch 13, wobei das Pilotsignal so angeordnet ist, dass es mit benachbarten Informationssignalen in der Inphasen- und Quadraturphasenebene einen Winkel von $\pi/4$ bildet.

15. System nach Anspruch 13, wobei das Einfügemittel das Pilotsignal auf die Amplitude nicht größer als das 1,6-fache einer maximal möglichen Amplitude der Informationssignale einstellt.

16. System nach Anspruch 13, wobei das Übertragungsmittel umfasst:

ein Mittel (30) zum Begrenzen eines Frequenzbands jedes Informationssignals mittels eines Roll-Off-Filters mit einem Roll-Off-Faktor im Bereich von 0,1 bis 0,4.

17. Mobiltelefon, das digitale Daten mit einer verminderten Bitfehlerrate überträgt, wobei das Mobiltelefon umfasst:

ein Übertragungssystem (10; 20; 110; 30; 40; 50; 60); und
ein Empfängersystem (70; 80; 100; 90), wobei das Übertragungssystem umfasst:

ein Umwandlungsmittel (10) zum Umwandeln der digitalen Daten gemäß einem Multipoint-Modulationsschema in einen ersten Strom von Informationssignalen mit vier oder mehr Signalpunkten auf einer Inphasen- und Quadraturphasenebene;
ein Einfügemittel (110) zum Einfügen eines Pilotsignals in den ersten Strom von Informationssignalen, um einen zweiten Strom aus den Informationssignalen und dem Pilotsignal zu erzeugen; und
ein Übertragungsmittel (30; 40; 50; 60) zum Übertragen des zweiten Stroms,

dadurch gekennzeichnet, dass ein Punkt des Pilotsignals auf der Inphasen- und Quadraturphasenebene in der Phase von jedem der Informationssignale abweicht und entweder auf der I- oder auf der Q-Achse der Inphasen- und Quadraturphasenebene angeordnet ist und eine Amplitude des Pilotsignals größer als die jedes der Informationssignale ist.

18. Mobiltelefon nach Anspruch 17,wobei das Einfügemittel das Pilotsignal auf die Amplitude nicht größer als das 1,6-fache einer maximal möglichen Amplitude der Informationssignale einstellt.

19. Mobiltelefon nach Anspruch 17, wobei das Übertragungsmittel umfasst:

ein Mittel (30) zum Begrenzen eines Frequenzbands jedes Informationssignals mittels eines Roll-Off-Filters mit einem Roll-Off-Faktor im Bereich von 0,1 bis 0,4.

Revendications

1. Procédé de transmission de données numériques sans fil dans un système de communications sans fil numérique, le procédé comprenant les étapes consistant à :

convertir des données numériques en un premier flux de signaux d'informations comportant quatre points de signaux ou plus sur un plan en phase et en quadrature de phase conformément à un principe de modulation à points multiples,
insérer un signal pilote dans ledit premier flux desdits signaux d'informations pour générer un second flux desdits signaux d'informations et dudit signal pilote, un point dudit signal pilote sur le plan en phase et en quadrature de phase différant en phase de l'un quelconque desdits signaux d'informations et étant placé sur chacun des axes I et Q du plan en phase et en quadrature de phase, et une amplitude dudit signal pilote étant supérieure à celle de l'un quelconque desdits signaux d'informations, et
transmettre ledit second flux sans fil.

2. Procédé selon la revendication 1, dans lequel ladite étape d'insertion d'un signal pilote comprend l'étape consistant à établir ladite amplitude dudit signal pilote pas plus grande que 1,6 fois une amplitude maximum possible desdits signaux d'informations.

3. Procédé selon la revendication 1, dans lequel ladite étape de transmission dudit second flux comprend l'étape consistant à :

limiter une bande de fréquences de chaque signal d'informations avec un filtre à coupure progressive présentant un coefficient de coupure progressive allant de 0,1 à 0,4.

4. Procédé selon la revendication 1, dans lequel ledit principe de modulation à points multiples est une modulation d'amplitude en quadrature à 2^m points de signaux, où m est un nombre entier positif pas plus petit que 3.

5. Procédé selon la revendication 1, dans lequel le principe de modulation à points multiples est une modulation de phase à quatre états.

6. Procédé selon la revendication 5, dans lequel ledit signal pilote est ainsi disposé de manière à réaliser un angle de $\pi/4$ avec des signaux d'informations dans ledit plan en phase et en quadrature de phase.

7. Procédé selon la revendication 5, dans lequel ladite étape d'insertion d'un signal pilote comprend l'étape consistant à établir ladite amplitude dudit signal pilote pas plus grande que 1,6 fois une amplitude maximum possible desdits signaux d'informations.

8. Procédé selon la revendication 5, dans lequel ladite étape de transmission dudit second flux comprend l'étape consistant à :

limiter une bande de fréquences de chaque signal d'informations avec un filtre à coupure progressive présentant un coefficient de coupure progressive allant de 0,1 à 0,4.

9. Système comprenant :

un moyen de conversion (10) destiné à convertir des données numériques en un premier flux de signaux d'informations comportant quatre points de signaux ou plus sur un plan en phase et en quadrature de phase conformément à un principe de modulation à points multiples,
un moyen d'insertion (110) destiné à insérer un signal pilote dans ledit premier flux desdits signaux d'informations pour générer un second flux desdits signaux d'informations et dudit signal pilote, et
un moyen de transmission (30 ; 40 ; 50 ; 60) destiné à transmettre ledit second flux sans fil,

caractérisé en ce qu'un point dudit signal pilote sur le plan en phase et en quadrature de phase diffère en phase de l'un quelconque desdits signaux d'informations et est placé sur chacun des axes I et Q du plan en phase et en quadrature de phase, et une amplitude dudit signal pilote est supérieure à celle de l'un quelconque desdits signaux d'informations.

10. Système selon la revendication 9, dans lequel ledit moyen d'insertion établit ledit signal pilote à l'amplitude pas plus grande que 1,6 fois une amplitude maximum possible desdits signaux d'informations.

11. Système selon la revendication 9, dans lequel ledit moyen de transmission comprend :

un moyen (30) destiné à limiter une bande de fréquences de chaque signal d'informations avec un filtre à coupure progressive présentant un coefficient de coupure progressive allant de 0,1 à 0,4.

12. Système selon la revendication 9, dans lequel ledit principe de modulation à points multiples est une modulation d'amplitude en quadrature à 2^m points de signaux, où m est un nombre entier positif pas plus petit que 3.

13. Système selon la revendication 9, dans lequel ledit principe de modulation à points multiples est une modulation de phase à quatre états.

14. Système selon la revendication 13, dans lequel ledit signal pilote est ainsi disposé de manière à réaliser un angle de $\pi/4$ avec des signaux d'informations adjacents dans ledit plan en phase et en quadrature de phase.

15. Système selon la revendication 13, dans lequel ledit moyen d'insertion établit ledit signal pilote à l'amplitude pas plus grande que 1,6 fois une amplitude maximum possible desdits signaux d'informations.

16. Système selon la revendication 13, dans lequel ledit moyen de transmission comprend :

un moyen (30) destiné à limiter une bande de fréquences de chaque signal d'informations avec un filtre à coupure progressive présentant un coefficient de coupure progressive allant de 0,1 à 0,4.

17. Téléphone mobile qui communique des données numériques à un taux d'erreurs sur les bits réduit, le téléphone mobile comprenant :

un système de transmission (10 ; 20 ; 110 ; 30 ; 40 ; 50 ; 60), et
un système de réception (70 ; 80 ; 100 ; 90), ledit système de transmission comprenant :

un moyen de conversion (10) destiné à convertir lesdites données numériques en un premier flux de signaux d'informations comportant quatre points de signaux ou plus sur un plan en phase et en quadrature de phase conformément à un principe de modulation à points multiples,
un moyen d'insertion (110) destiné à insérer un signal pilote dans ledit premier flux desdits signaux d'informations pour générer un second flux desdits signaux d'informations et dudit signal pilote, et
un moyen de transmission (30 ; 40 ; 50 ; 60) destiné à transmettre ledit second flux,

caractérisé en ce qu'un point dudit signal pilote sur le plan en phase et en quadrature de phase diffère en phase de l'un quelconque desdits signaux d'informations et est placé sur chacun des axes I et Q du plan en phase et en quadrature de phase, et une amplitude dudit signal pilote est plus grande que celle de l'un quelconque desdits signaux d'informations.

18. Téléphone mobile selon la revendication 17, dans lequel ledit moyen d'insertion établit ledit signal pilote à l'amplitude pas plus grande que 1,6 fois une amplitude maximum possible desdits signaux d'informations.

19. Téléphone mobile selon la revendication 17, dans lequel ledit moyen de transmission comprend :

un moyen (30) destiné à limiter une bande de fréquences de chaque signal d'informations avec un filtre à coupure progressive présentant un coefficient de coupure progressive allant de 0,1 à 0,4.

FIG. 1

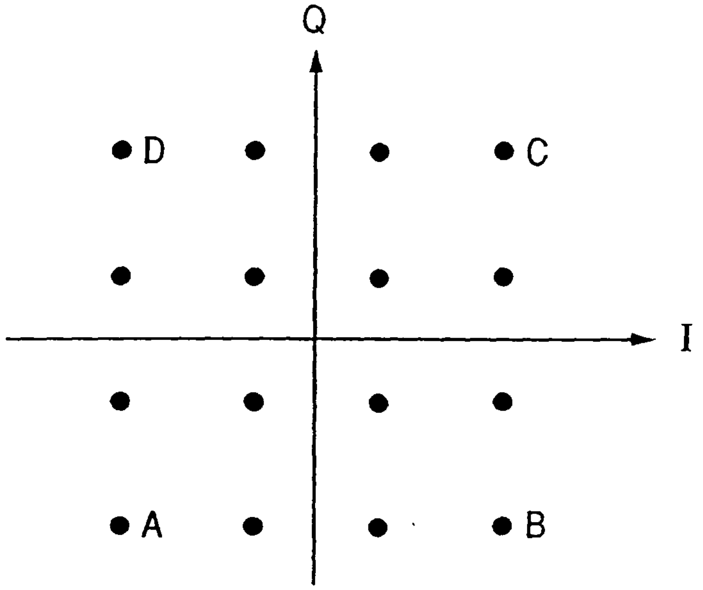


FIG. 3

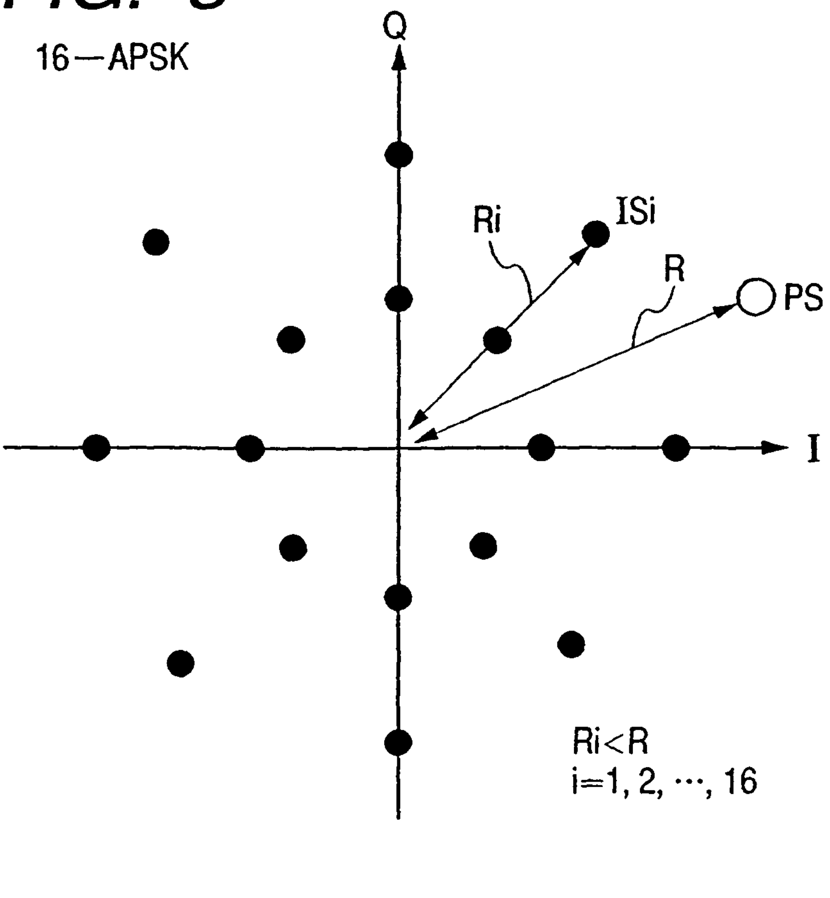


FIG. 2

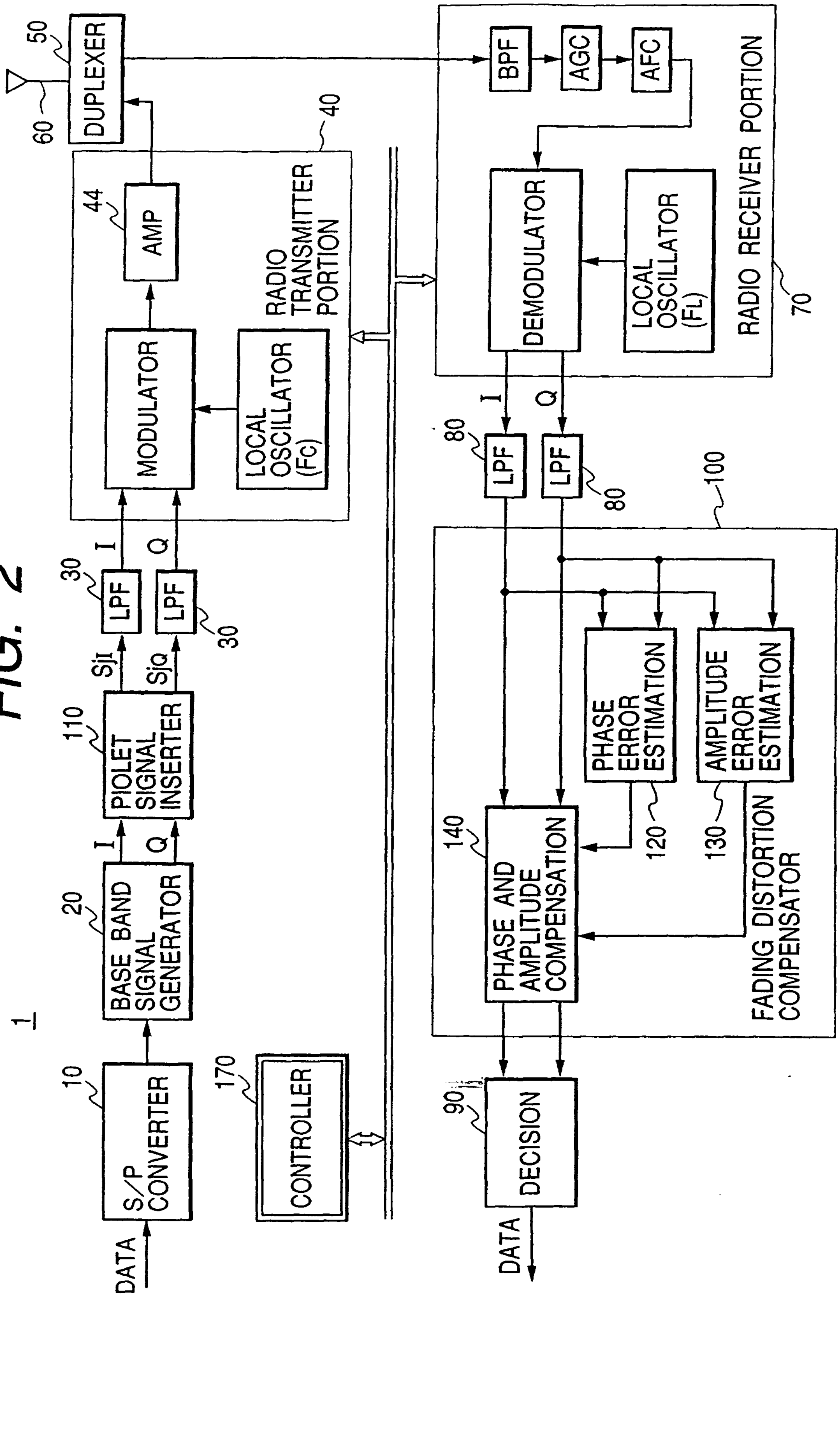
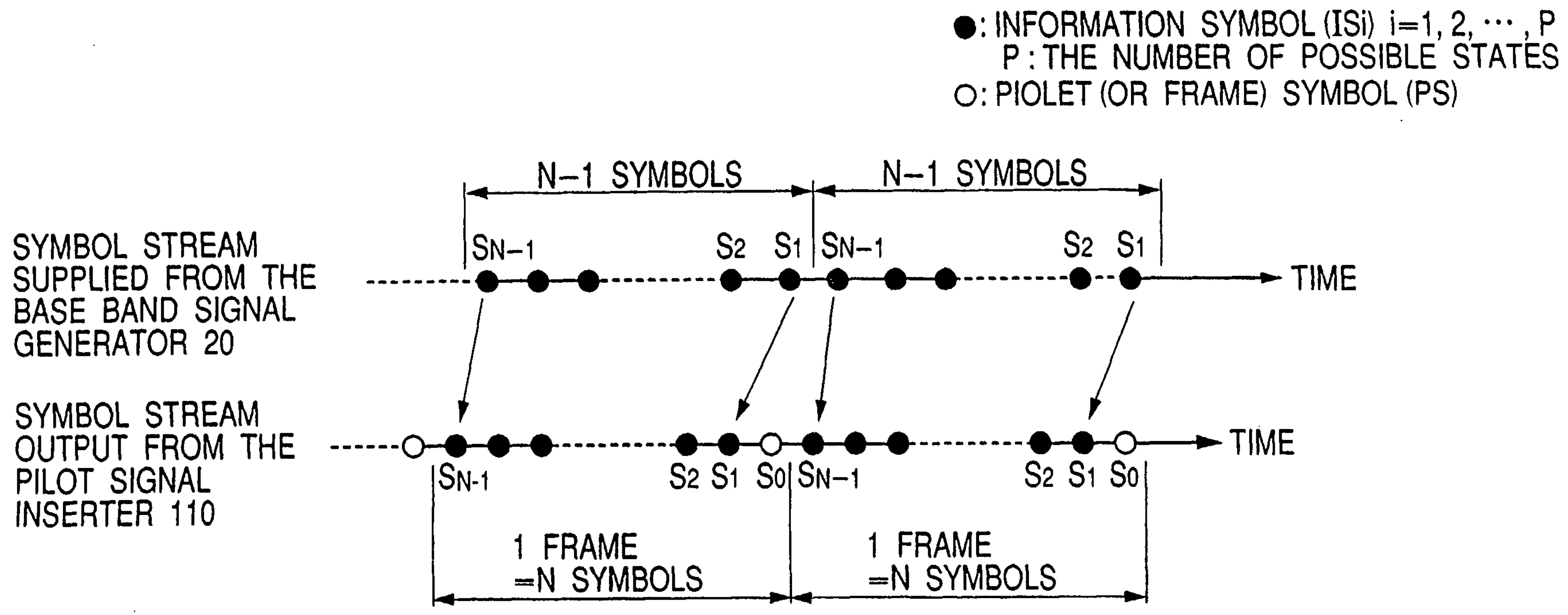

1
DATA
10
S/P CONVERTER
20
BASE BAND SIGNAL GENERATOR
I
Q
110
PIOLET SIGNAL INSERTER
SjI
SjQ
30
LPF
LPF
30
I
Q
MODULATOR
LOCAL OSCILLATOR (Fc)
44
AMP
RADIO TRANSMITTER PORTION
40
60
DUPLEXER
50
170
CONTROLLER
BPF
AGC
AFC
DEMODULATOR
LOCAL OSCILLATOR (FL)
RADIO RECEIVER PORTION
70
I
Q
80
LPF
LPF
80
100
PHASE ERROR ESTIMATION
AMPLITUDE ERROR ESTIMATION
120
130
140
PHASE AND AMPLITUDE COMPENSATION
FADING DISTORTION COMPENSATOR
90
DECISION
DATA

FIG. 4

OPERATION OF THE PILOT SIGNAL INSERTER 110



$$S_j = \begin{cases} PS \text{ FOR } j=0 \\ ISi \text{ FOR } j=1,2,\cdots,N-1 \end{cases}$$

FIG. 5

2^m—QAM

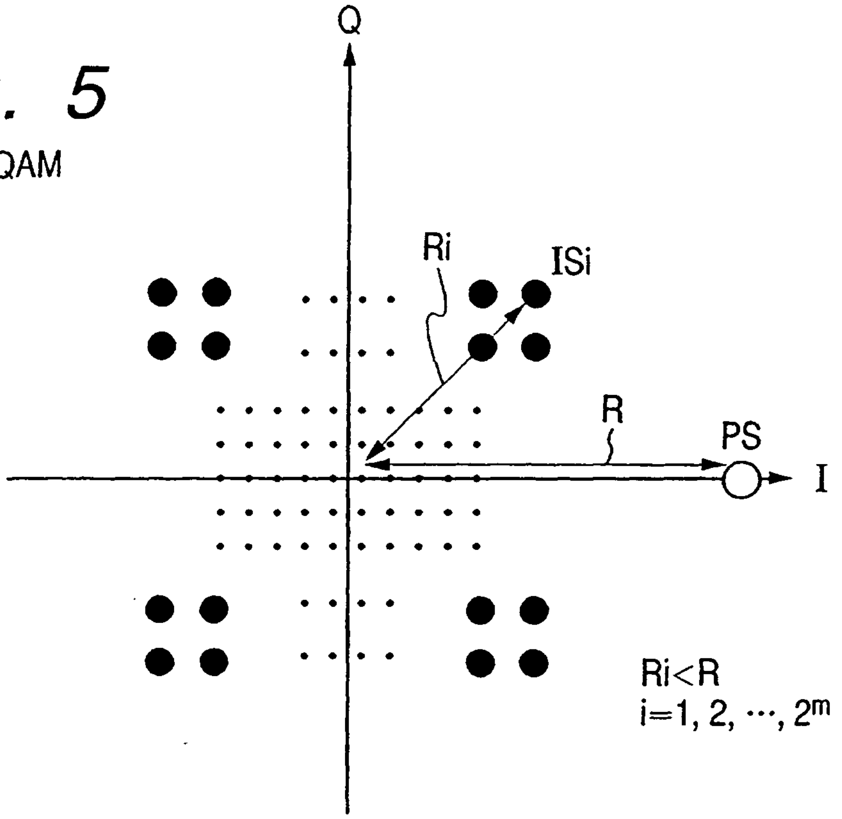


FIG. 6

16—QAM

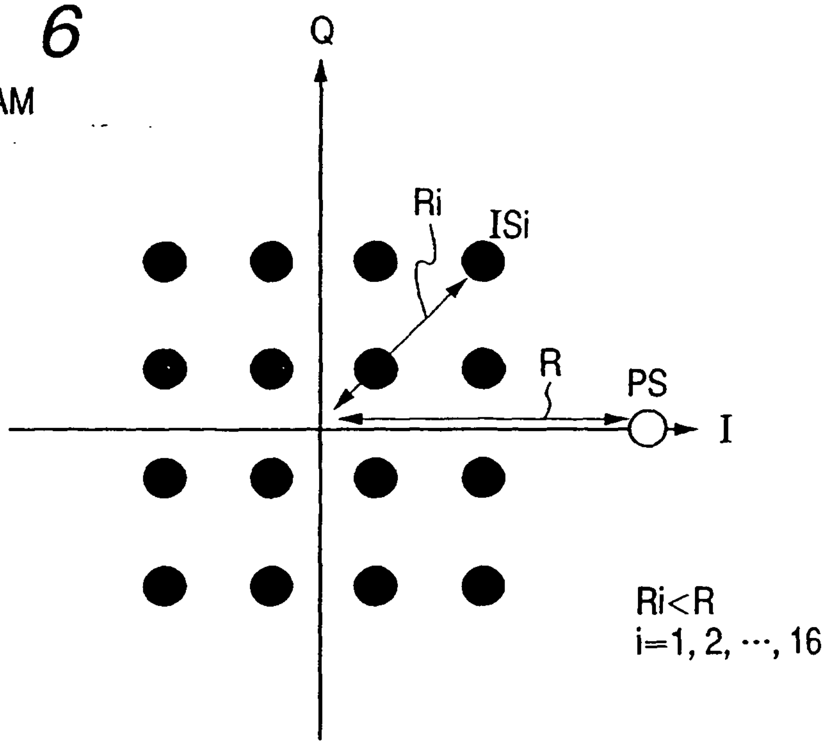


FIG. 7

8—PSK

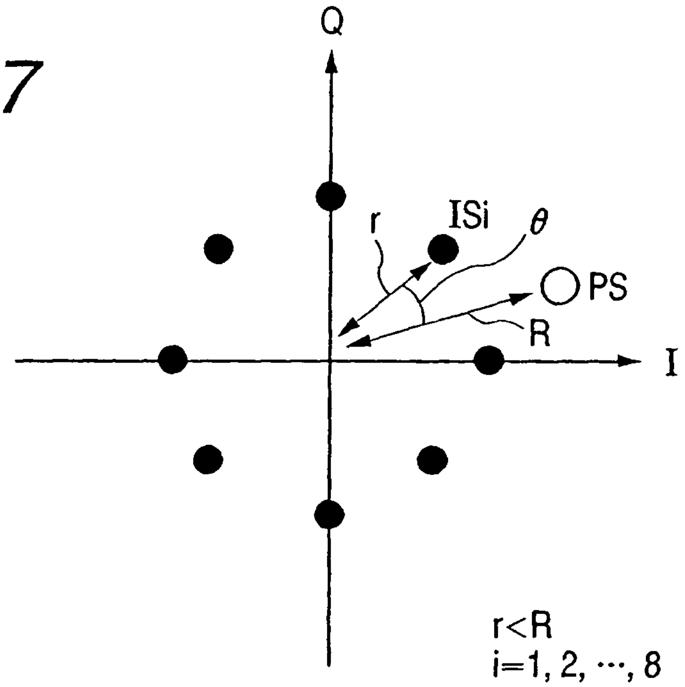


FIG. 8

QPSK